AD-A047 620 DEFENSE SYSTEMS MANAGEMENT COLL FORT BELVOIR VA F/G 5/1
VERT - A RISK ANALYSIS TECHNIQUE FOR PROGRAM MANAGERS.(U)
MAY 77 T N THOMAS

UNCLASSIFIED NL

| OF |

AD
A047 620

END
DATE
FILMED
1 -78
DDC

0

AD-A047620

DEFENSE SYSTEMS MANAGEMENT COLLEGE

DEPARTMENT OF DEFENSE
SYSTEMS MANAGEMENT COLLEGE
DUCTUS DOCTRINA DOMINATO

PROGRAM MANAGEMENT COURSE
INDIVIDUAL STUDY PROGRAM

VERT - A RISK ANALYSIS
TECHNIQUE FOR PROGRAM
MANAGERS

STUDY PROJECT REPORT
PMC 77-1

THOMAS N. THOMAS
MAJOR USA

FORT BELVOIR, VIRGINIA 22060

VERT - A RISK ANALYSIS TECHNIQUE FOR PROGRAM MANAGERS

Study Project Report

Individual Study Program

Defense Systems Management College

Program Management Course

Class 77-1

by

Thomas N. Thomas
Major USA

May 1977

Study Project Advisor
Maj. Carlton F. Roberson, USA

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) VERT - A RISK ANALYSIS TECHNIQUE FOR PROGRAM MANAGERS		5. TYPE OF REPORT & PERIOD COVERED study Project Report 77-1 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) THOMAS N. THOMAS		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS DEFENSE SYSTEMS MANAGEMENT_ COLLEGE FORT BELVOIR, VA 22060		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS DEFENSE SYSTEMS MANAGEMENT COLLEGE FORT BELVOIR VA 22060		12. REPORT DATE 77-1 13. NUMBER OF PAGES
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) UNCLASSIFIED 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

UNLIMITED

DISTRIBUTION STATEMENT A
Approved for public release;
Distribution Unlimited

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

SEE ATTACHED SHEET

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

DEFENSE SYSTEMS MANAGEMENT COLLEGE

STUDY TITLE: VERT - A RISK ANALYSIS TECHNIQUE FOR PROGRAM MANAGERS

STUDY PROJECT GOALS: To describe the capabilities of the VERT (Venture Evaluation and Review Technique) risk analysis technique and to review its current applications in support of the program manager (PM).

STUDY REPORT ABSTRACT: PM's are continuously faced with making decisions without complete certainty of their impact. These decision situations involve certain risks or probabilities concerning the time, cost and technical performance effects. New techniques have been evolving to assist decision makers (e.g., PM's) in this risk environment. VERT is a network simulation modeling technique recently developed to provide this assistance.

This report examines VERT's capabilities and procedures for conducting a risk analysis. This discussion is presented in non-technical terms.

From information collected through interviews with Army and Navy personnel supporting PM's, a profile of current VERT applications and their effectiveness is developed. Applications discussed vary from the support of major programs like the AAH (Advanced Attack Helicopter) to smaller efforts like the PEWS (Platoon Early Warning System).

The report concludes with recommendations for further studies on risk analysis techniques and for an increased effort to disseminate information and experiences about VERT throughout the Systems Acquisition Community.

SUBJECT DESCRIPTORS: Risk Analysis, Costs, Scheduling, Network Flows, Decision Analysis.

NAME, RANK, SERVICE	CLASS	DATE
Thomas N. Thomas, Maj., USA	PMC 77-1	11 May 1977

EXECUTIVE SUMMARY

The purpose of this study is to review the capabilities of the risk analysis technique, VERT (Venture Evaluation and Review Technique) and to discuss its recent applications to assist Program Managers. Information for the preparation of this report was primarily obtained through informal telephone interviews with personnel who have conducted VERT analyses.

VERT uses a simulation approach to analyze decision situations involving risk. The model is easy to use and its variety of program functions allows analysis of complex decisions involving many interrelated risk situations (activities).

This relatively new technique has been applied in a broad range of program development situations. This report discusses some applications in support of Army and Navy programs. These applications included analysis of development schedules, production costs and schedules, and system configuration alternatives. In most applications, the major concerns were cost and schedule risks. Analyses where technical performance risk is the major concern have been limited.

In addition to its risk analysis function, VERT is being used to perform sensitivity analyses and in one case to track an acquisition program's progress. In these two applications VERT provides the decision maker with information which can be a great benefit in answering "What if" questions.

The report concludes that VERT is a powerful and flexible tool which can be of great assistance to decision makers. However, the capabilities of VERT are not well known, and consequently the potential of this technique is not being realized within the systems acquisition community. Further investigation into the current uses of VERT and suggestions for increased efforts to inform program management personnel about VERT are some recommendations resulting from this study.

ACKNOWLEDGEMENTS

Appreciation is expressed to Major Carlton Roberson for his assistance in refining the scope of this study effort and his helpful suggestions throughout its conduct. A special thanks is given to the personnel who graciously helped me in this investigation by discussing their experiences with VERT. These individuals were Ms. Reed, Mr. Moeller, Mr. Bradley, Mr. Fiscilla, Mr. Pearcy, Mr. Schapiro and Mr. Blankenship.

TABLE OF CONTENTS

CHAPTER I

INTRODUCTION

Background

One of the most pervasive and recurring situations encountered in Program Management is the requirement to make decisions with incomplete or inadequate information about the alternatives. These "decisions under risk" situations occur more frequently in Weapons Systems Acquisition Program Management than in many other areas of management. This is because the Program Manager (PM) is involved in the development of new technologies or the use of existing technologies in new applications. The risks encountered by the PM relate to the three general categories of cost, schedule and technical performance.

To assist the PM in making decisions under risk many techniques have been developed and used over the past years. Linear Programming, Game Theory and various modeling techniques are some examples. One of the most popular modeling approaches in recent years for complex problems has been the math modeling technique called "simulation." The easy accessability to large scale general purpose computers has made this technique a valuable tool for the PM.

Purpose

The intent of this report is to discuss and to some degree comment upon recent and possible future uses by Defense PM's of

a simulation risk analysis technique called VERT (Venture Evaluation Review Technique)(8)[1].

Objectives

The objectives of this study were:

1. To investigate the functional capabilities and procedural requirements of VERT.

2. To review with the users their recent attempts and future plans to use VERT as a supportive tool in the decision process. This objective was oriented to identifying what types of risk were considered in VERT simulations and what types of problems were encountered in the development and running of the VERT model.

3. To develop a foundation of information concerning the VERT model and identify areas for further investigation.

4. To make recommendations concerning the future use of VERT by the Systems Acquisition Community.

Scope

Because of time and travel constraints this investigative effort was necessarily limited to readily accessible documentation and informal discussions with some selected personnel who have used VERT to assist PM's in decision analyses. Only

[1]This notation will be used throughout the report for the sources of quotations and major references. The first number is the source listed in the bibliography. The second number is the page in the reference if appropriate.

military organizations have been contacted. However, since VERT was developed at Rock Island Arsenal just a few years ago, few non-military organizations are presently aware of the model.

Definitions

Model: An imitation or artificial representation of a real world object or system used to make predictions concerning the performance of the item under real world conditions.

Simulation: A stochastic (probalistic) modeling technique which provides outputs depicting the probability distributions of possible outputs expected from the real world item.

Methodology

This study effort was conducted in three phases.

First the functional description of VERT was reviewed by the author to develop an appreciation for its capabilities and complexities.

The second effort involved contacting nine known users of VERT to determine their willingness and availability to participate in an informal telephone interview discussing their experiences with VERT. Subsequently an outline of the proposed interviews was developed and provided to six individuals prior to the conduct of the interviews. One to two weeks following the forwarding of the proposed interview, the interviews were conducted.

The final phase of the study involved an analysis of the data collected from the interviews and a survey of additional documentation received from the Defense Logistics Studies

Information Exchange (DLSIE) library. The results of this analysis served as the basis for this study report.

CHAPTER II

THE VERT MODEL

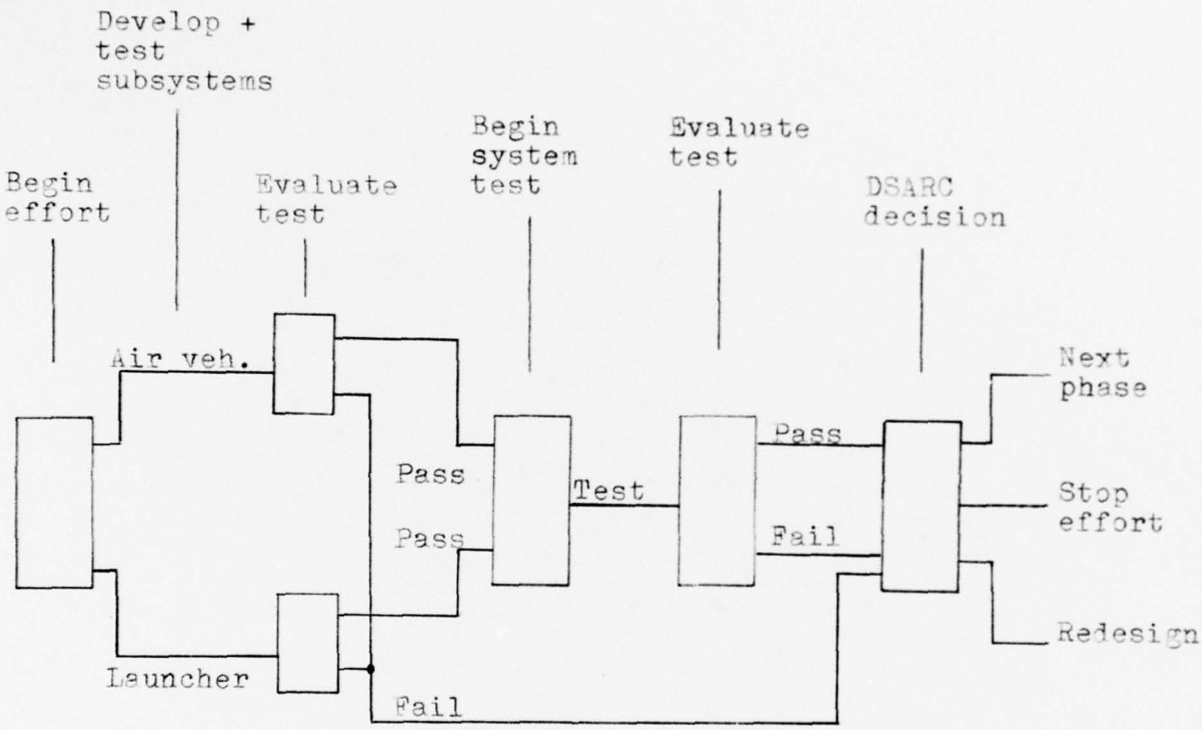
General Description

The VERT simulation model uses a general networking approach to structuring risk situations to be analyzed[2]. This approach allows the visual depiction of all interrelated actions which may occur. Figure 1 shows a very general network depicting a phase in the development of a hypothetical missile system. At certain points (nodes) in the network, decisions are made which determine the next path to be followed in the network. The new path selected at these decision points is determined by probabilities or some criteria specified by a mathematical relationship (8:9). Although this (Fig. 1) is a very simplified depiction of missile system development, more detailed and complicated situations can be easily described by this type of network.

Once the network is developed it is converted to the VERT program terminology. The program has a variety of input capabilities which allows the description of the decision events and activities occurring in the network. The likelihood of any

---

[2]In the context of this report, risk situations are those where an action (decision) may cause several outcomes each of which has a certain probability of occurrence.



Decision flow network of
Missile System Development
Figure 1

activity occurring can be accurately described by the many common forms of probability distributions included in the program (See inclosure 1). In addition, the relationship of variables such as time and cost can be defined for the program as a mathematical relationship (i.e., $C = aT + b$).

A final characteristic which makes VERT a desirable tool to use is the output options available. The program provides distributions depicting the frequency at which certain paths through the network were followed. It also provides distributions showing the costs and time involved in traversing the different paths.

You don't have to be a computer programmer or systems analyst to effectively utilize VERT. An individual in a Program Office, familar with basic mathematics and computer programming should be able to productively use VERT after several hours of study. Complete mastery of all the model's capabilities probably would require a week of continuous effort (8:4) . However, such proficiency would only be required in simulating very complex or unique risk situations. Actually, even in the most complex situations, the programming can be simplified to a great degree by breaking down the network into subnetworks. Then using the simple program functions (operators), the subnetworks can be simulated. The results of these simulations can then be used as inputs to a higher level, more general network simulation which ties all the subnetworks together. There may be some loss of accuracy in the final results from this two-step approach.

However, considering the chances of error, and the time involved in solving the complex network, this loss of accuracy may be acceptable.

In contrast to VERT's capability to simulate complex risk situations, it can also be simplified to the extent that it performs the same general functions as PERT (Program Evaluation Review Technique)/CPM (Critical Path Method). By setting one of the VERT decision point output probabilities to 1 and the others to zero, the network collapses to one similar to a deterministic PERT/CPM network. The use of VERT in this manner however is a waste of effort. More efficient programs exist for the analysis of networks describing situations without risk.

VERT Procedures

The process of setting up and conducting a VERT analysis can be summarized into five basic steps which many times may require iterations before the model accurately depicts the real world situation.

1. The first effort is to define the decision (risk) situation to be analyzed and to specify the objectives of the analysis.

For instance in the hypothetical missile system mentioned earlier, the risk situation included all the development actions, the decisions which were to be made and their interrelationship in terms of time, cost and technical performance. The major objective of this analysis could be to determine the probability

of going into production. Imposed upon this could be the objectives to determine the cost and time involved in reaching production. In addition, the decision maker may want to know the money and time wasted if a decision to go into production is not made.

The situation description developed during this step should be approved by the decision maker before proceeding to the following steps.

2. In this step, the situation defined during step 1 is depicted in a network. This visual depiction of the risk situations helps to further refine the description developed in the first step. Errors made in verbally describing the situation often become evident at this point. Figure 1 is an example of a descriptive network produced during this effort.

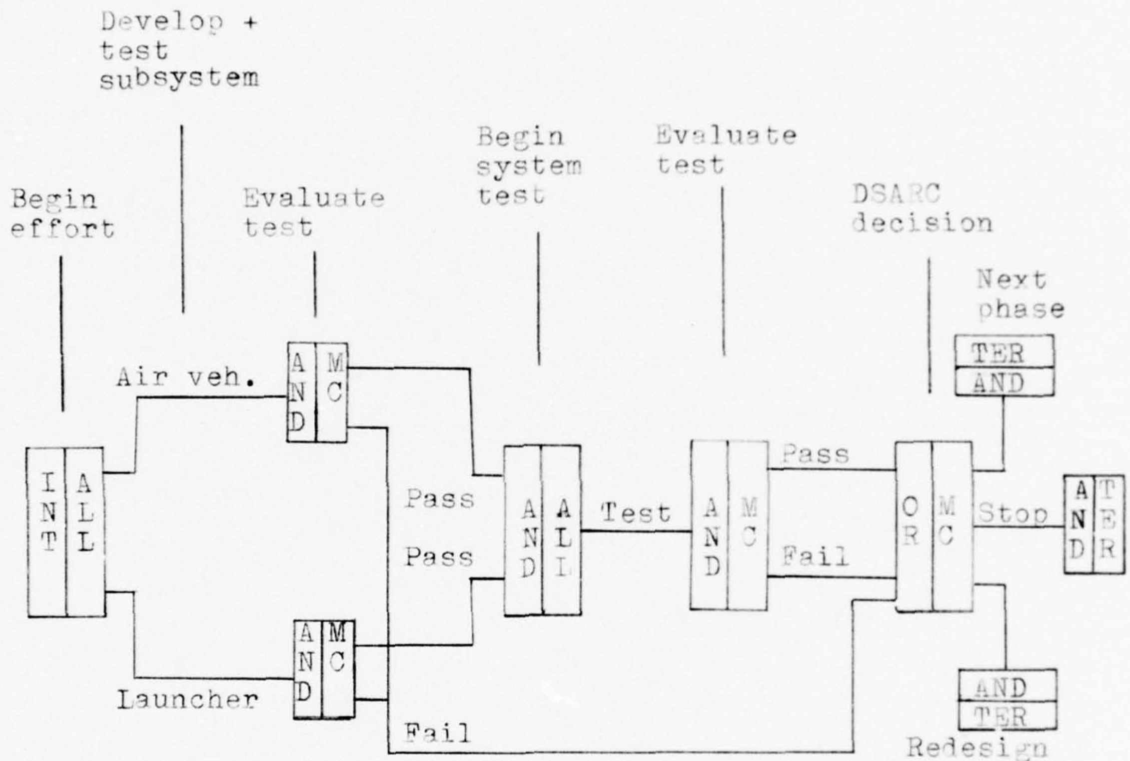
3. Concurrently, with step 2, the data necessary to describe the activities and decision processes should be collected. This data is then organized into some form of a probability distribution or described by a mathematical equation.

4. The next effort is to transform the network developed in step 2 to a network which will facilitate programming. This involves showing the decisions and activities by the use of the logic operators of the VERT program and the conditions developed in step 3. There are many possible solutions to this transformed network and every user will probably accomplish this differently (8:4). The important point is to insure it accurately describes the decision process of the original network.

The transformed network for the hypothetical missile system is shown in figure 2. A detailed discussion of the program operators used here will not be attempted but it can be obtained from the author (7:8-13). However, as an example of the meaning of the transformation, consider the notations (AND/ALL) at the beginning of the "total systems test" (figure 2). These operators require all the incoming paths to have been successfully completed before it allows the simulation to perform the next function. In the missile situation it means that total system test will not begin until all subsystem tests are satisfactorily completed. The activities involving risk like the "development of a subsystem" show reference (A-3) to a table of probabilities which will be used in the program to describe the possible outcomes of the effort.

After this transform is complete, the information is entered in a computer program and the simulation is run. The number of iterations or runs of the program is determined by the specified confidence level of the desired results.

5. The final step is the analysis of the simulation results. The outputs from the simulation will be in the form of distributions indicating the frequency of occurrence of the different outcomes or the distribution of costs and time involved. For instance a cost distribution would show the average cost and the range of values which might occur. Many other statistics describing the simulations operation can be obtained as output from the program. Analysis of all the output information will provide the



VERT network of
Missile System Development
Figure 2

decision maker with an improved understanding of the risks involved in his decision situation.

Another benefit can be realized once step 5 has been reached. It now becomes quite easy to rerun the model using variances of the original conditions. This form of sensitivity analysis will provide the decision maker with answers to many of the "What if" questions. For instance, "What if the subsystem test of the air vehicle is two weeks (average) longer than originally expected?" A change of probably one punched card could be made and the entire simulation rerun in a very short period of time. The new outputs would provide the decision maker with good indications of the effects of this hypothetical contingency.

In summary, the VERT model is flexible, powerful and in most cases easy to use.

CHAPTER III

RECENT PM APPLICATIONS OF VERT

The VERT modeling technique evolved a few years ago as an improvement over existing risk analysis techniques such as RISCA (Risk Information System for Cost Analysis (6)). VERT is an improvement over most existing models in three areas. It offers a wider range of functions (decision logic) to describe decision actions and activities. It has greater internal capability for specifying the probability of activities. Finally, it provides increased output options for describing the performance of the simulation model.

This technique has been used in support of several Army and at least one Navy program. In the following discussion, a profile will be developed describing these current applications of VERT. The majority of the information to support this discussion was obtained by informal telephone interviews (see bibliography).

Users

Although the PM is the ultimate user of the VERT analysis, the simulations to date have been developed and run by functional offices (normally called System Analysis Offices) belonging to the Headquarters supporting the PM. In all but one case, the offices contacted indicated they were sufficiently staffed with analysts and programmers to handle their present risk-decision

analysis requirements. In addition to VERT, these offices use other risk analysis tools such as RISCA and decision trees.[3] One systems analysis office has even developed a computer program (DETRAK) to analyze decision trees (10).

The PM's who have received VERT simulation support vary from the major programs like the XM-1 tank program (3) and the AAH (Advanced Attack Helicopter)(13) program to the small efforts like PEWS (Platoon Early Warning System) ground sensor project (12). VERT has also been used by a laboratory in the development of a new muzzle break for artillery (5). In the Navy, VERT was used in support of the F-18 (Navy fighter airplane) program (2).

Applications

To date the majority of uses of VERT have been concerned with cost/schedule risk situations. Only one of the individuals interviewed had attempted to use VERT in estimating technical risk.

In support of the Cannon-Launched Guided Projectile program a VERT simulation was designed to examine the probability that the development effort would successfully reach the production phase. Major risks considered in this analysis were DT/OT II and III and the probabilities of the two Low Rate Initial Production (LRIP) contractors producing hardware acceptable for

---

[3]Decision trees are networks normally used to analyze decision situations using single variables (e.g, cost) and exact probabilities (versus probability distributions). The path providing the maximum benefit is normally selected.

full production. Also included in the analysis was the DSARC III and IIIa decision points (1).

In another application, VERT was used to determine the cost/schedule risks involved in achieving the planned IOC (Initial Operational Capability) for the M110E1 self-propelled howitzer using a new propellant charge and new gun tubes. The major risk areas considered in this situation were manufacturing problems, acceptance testing (including test firings) and shipping delays.

In the case of the AAH program, VERT was initially used to evaluate the planned and alternate validation phase schedules through DSARC II. Of course, at this stage of development there is considerable risk in many areas. The major value of this analysis would be to show all the possible impacts from activities which may not occur as planned. In effect it allows you to determine critical paths through a network full of uncertainties. This first effort was so well received by the AAH PM that he is now asking for continuous tracking of his program by VERT simulation.

In support of PEWS, the Army Electronics Command conducted an analysis of several configuration options. The objective of the effort was to determine viable alternatives to the proposed configuration and to quantify their cost and schedule impacts.

The one analysis which considered technical performance was performed by the Navy. Their effort was concerned with whether to test a certain radar in a laboratory environment or if the risks were

great enough to require actual flight tests aboard an aircraft. The risks were related to the amount of new technology involved. This particular analysis was conducted "after the fact." The decision had already been made and the analysis was conducted as their first attempt to use VERT. When provided the results the PM believed the analysis would have provided him valuable information in preparing to make the decision.

In two other applications encountered VERT was used to evaluate optional approaches to satisfy a requirement. The option of an automatic, general purpose test equipment was compared to special purpose test equipment in one case. In the other case the options of operating a depot activity with contractor personnel was compared to the use of military personnel.

Although other applications of VERT exist, the above examples reflect the broad range of applications possible with this technique.

Problems

Several comments were obtained from the interviewees, which indicated some minor problems or needs for improvement had been encountered in their particular environments. None of these problems are considered major impediments to the acceptance or effective utilization of VERT. In fact many of these comments have been provided Mr. Moeller, the author of VERT, who has already incorporated many changes in his program. In other cases, the users have made local modifications to solve their particular problem. One agency has modified the program to provide graphic

displays of the networks and plotter outputs (12). Another agency has modified their input format to make VERT more accessible to personnel without programming experience (11).

The most frequently addressed problem was not related to the VERT program itself but was concerned with the collection of data needed to describe the probablistic behavior of the variables (time, cost and technical performance). Although VERT allows the use of many different distributions, in most previous cases the best distributions used were triangular. This procedure doesn't really use the capability of the model and reduces the accuracy of the simulation results.

Another problem related to the data is not obtaining accurate estimates of the time and cost from the "experts." Data frequently had to be rechecked several times to insure its validity. Data sources (experts) have consistently given overly optimistic estimates. In some cases this has persisted until the data sources have understood the data was to be used in a VERT simulation only and would not appear in other documents which could cause them embarrassment.

Although not a VERT problem, the fact that VERT is not frequently used could imply problems exist. However, there are several plausible reasons for this lack of use other than a weakness in VERT.

1. The VERT model has only been available for about 4 years. Experiences with and documentation of its use has been limited. Consequently, program management office personnel are unaware

of its existence and potential applications in the program development environment.

2. The time a PM allows a systems analysis office to produce a risk analysis is often too short to allow the set up of the program and the development of probability estimates. The actual amount of time required is related to the complexity of the situation being modeled and the availability of related historical data.

3. Many Army organizations who provide VERT analysis support have been reorganizing the past few years. As a result, they have had little time to try new techniques or to educate program office personnel about the capabilities of this new technique.

4. VERT has not been taught or publicized to any significant degree within the System Acquisition Community. However, recently the Army Logistics Management Center (Ft. Lee, Va.) has incorporated some discussion of VERT in their advance risk analysis course (14).

Results

VERT simulation results provide the user a considerable amount of information describing the possible real world impacts resulting from risk situations.

The results of the Cannon-Launched Guided Projectile programs' VERT simulation (mentioned earlier) provided some insight to potential future actions. The simulation indicated that there was a 95% chance of at least one LRIP manufacturer qualifying

for full production. It also indicated the total cost of the program would be about $9 million over baseline cost with a 9 month (90% confidence level was ± 10 months) stretched out in the schedule (1:4).

In the self-propelled howitzer simulation the results indicated IOC would be achieved 13½ months (90% confidence level was ± 1 month) after initiation of the effort. This indicated about a 1 month delay in the planned IOC. The major risk determined from analysis of the results was the timely commitment of funds (9:11).

A final example of VERT simulation results is provided by the configuration management analysis conducted in support of PEWS. Several of the alternatives to the PEWS configuration of sensors were considered feasible. One system component however was considered a high risk item due to a design improvement which was required. This improvement required a high cost investment and a 16-month delay in IOC for anticipated marginal performance improvements. The analysis indicated the item could be replaced by another item with minimum impact on PEWS effectiveness. One additional point highlighted by the analysis was the savings of $1.5 million by selection of one of the feasible alternatives.

Every interviewee stated the PM they supported was satisfied with the analysis provided by the VERT simulation.

By his actions, one PM has indicated a high degree of confidence in the use of VERT. He is now having the systems analysis office track his program using VERT. When actual events

change the risk situations, he will be provided new assessments of risk and probable impacts of any decisions he makes. Because of this PM's demonstrated interest, this systems analysis office plans to expand their VERT efforts to other programs. They are also developing an education program to be used to train program office personnel to set up VERT networks and to analyze VERT simulation results. Finally, this office is preparing a "paper" to present at the Army Operations Research Systems Analysis Symposium this fall. The "paper" will address their use of VERT to track a development program (13).

The discussion in this chapter shows the diverse types of risk situations which can be analyzed using the VERT model. It seems apparent from the interviews conducted that the VERT model can be a very beneficial tool for program management once personnel are aware of its availability and capability.

CHAPTER IV

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Although only a limited survey was conducted, it included four different Army Commands which provide functional support to many of the Army's PM's. Based upon these informal comments and some documented VERT applications a few general comments can be made.

1. The systems analysts have found VERT to be a flexible and potentially powerful tool for the conduct of risk analyses. All the personnel interviewed felt VERT was the best tool available to solve complex risk problems. They have found VERT programs easy to set up, run and analyze. Even though some users have made modifications to the program, in general they feel the program has sufficient programming capabilities.

2. Program Managers seem to be satisfied with the results of risks analyzed using VERT.

3. VERT appears to be well suited to analyzing risks involving time and schedule. It also appears to have great potential to solve technical risk problems, but experience in this area has been so limited that no conclusion can be made.

4. Present users of VERT are not obtaining maximum benefit from the model because they normally use triangular (Best, Worst and most likely estimates) distributions to describe variable probabilities. Apparently this is caused partly by the lack of

time available to develop more accurate depictions of the variables and partly by the lack of experience in new areas of technology. When working in these new areas where historical data is not available the triangular and uniform (equally probable) distributions may be the best estimates possible.

5. VERT can be used to analyze a wide range of risk situations. It has been used to make decisions involving hardware testing, low rate initial production and configuration management. VERT analyses have been conducted on both simple and complex networks. However, when the networks become extremely complex, it is usually appropriate to develop subnetworks, solve these independently and then use these outputs as inputs to the final general network.

Recommendations

In the hope of improving the understanding of VERT within the Acquisition community, the following recommendations are made.

1. An information paper should be developed and disseminated to all Acquisition Agencies explaining the benefits of VERT and identifying activities providing VERT risk analysis service.

2. As the focal point of Systems Acquisitions knowledge for the services, DSMC should incorporate into its curriculum, instruction concerning VERT as a new decision analysis tool for

PM's. Providing this instruction should serve as a strong stimulus to increasing and improving the use of VERT. To keep this instruction meaningful the college should develop and maintain a data base on the latest applications of VERT within the acquisition community.

3. A technical reference library (file) of risk analysis models used by PM's and of documents discussing their application should be established and maintained at DSMC.

4. A profile of the personal reactions of PM's to VERT should be developed (by interviews) and analyzed to estimate the actual benefit being achieved by using VERT. This investigation should include determining if the PM's made the decision indicated by their VERT analysis. It should also be ascertained to what degree subsequent occurrences substantiated the model's predictions.

5. A representative from DSMC should attend the next OR/SA Society convention (Fall 1977) to obtain information from a paper being presented on the use of VERT as a program tracking tool. This recommendation is supportive of recommendation #2.

6. To improve the efficacy of the VERT model in support of Acquisition decisions, system analysts should be encouraged to develop more representative probability distributions. At a minimum, parametric estimates based on historical data can be developed at an acceptable cost. Implementation of recommendation #2 will be helpful in this effort by impressing upon PM personnel the importance of using the best estimates that can be reasonably developed.

BIBLIOGRAPHY

1. Besson, James B., Risk Analysis of the 155MM Cannon-Launched Guided Projectile, Rock Island, Illinois: U.S. Army Armament Command, 1976.

2. Blankenship, Edward DNC, Weapon Systems Analysis Office, Naval Weapons Systems Support Activity, Washington, D.C. Telephone interview conducted (Local 433-3621) on 4 April 1977.

3. Bradley, Paul, DAC, Systems Analysis Office, U.S. Army Tank and Automotive Command, Warren, Mi. Telephone interview conducted (Av 273-2379) in March 1977. Mr. Bradley has used VERT in support of the XM-1 Tank Program.

4. Bevelhymer, Herbert L., A Proposed Methodology for Weapons System Development Risk Analyses, Wright Patterson Air Force Base, Ohio: Armed Forces Institute, 1973.

5. Fiscilla, Russell R., DAC, Benet Weapons Laboratory, U.S. Army Armament Command, Watervilet, N.Y. Telephone interview (Av 974-5813) conducted 30 Mar 1977. Mr. Fiscilla used VERT in the development of a new muzzle break for Army artillery.

6. Knight, James R., Comparison of PERT and PERT/Cost with RISCA and RISNET, U.S. Army Logistics Management Center, Ft. Lee, Va., 1974.

7. Lenox, Hamilton T., Risk Assessment, Wright Patterson Air Force Base, Ohio: Armed Forces Institute, 1973.

8. Moeller, Gerald, VERT Documentation, Rock Island, Illinois: U.S. Army Armament Command, 1976.

9. Paarman, Arthur W., Risk Analysis of the M110E1 Self-Propelled Howitzer, Rock Island, Illinois: U.S. Army Armament Command, 1976.

10. Pearcy, Stephen B., DETRAK: A Computor Program for Evaluating Decision Trees, Picatinny Arsenal, Dover, N.J., 1973.

11. Pearcy, Stephen B., DAC, System Evaluation Office, U.S. Army Armament Command, Dover, N.J. Telephone interview (Av 880-5765) conducted in March 1977. Mr. Pearcy has used VERT in support of the Cannon-Launched Guided Projectile Program.

12. Reed, Susan, DAC, Systems Analysis Office, U.S. Army Electronics Command, Ft. Monmouth, N.J. Telephone interview (Av 992-4325) conducted in March 1977. Ms. Reed's office has used VERT on several programs to include the Platoon Early Warning System.

13. Schapiro, Paul B., DAC, Systems Analysis Office, U.S. Army Aviation Systems Command, St. Louis, Mo. Telephone interview (Av 698-6911) conducted on 20 April 1977. Mr. Schapiro is using VERT in support of the Advanced Attack Helicoptor.

14. Toliver, Donald, Cpt., USA, U.S. Army Logistics Management Center, Ft. Lee, Va. Telephone interview conducted (Av 687-4572) in February 1977. Cpt. Toliver is an instructor in the Risk Analysis.

15. ________________, Venture Evaluation Review Technique (VERT) Analysis of the Platoon Early Warning System (PEWS), unpublished report, Ft. Monmouth, New Jersey; U.S. Army Electronics Command, no date.

VERT PROGRAM DESCRIPTORS

1. Some distributions available to describe program activities (processes)

   a. Histogram
   b. Uniform
   c. Triangular
   d. Normal
   e. Gamma
   f. Log Normal
   g. Gamma
   h. Erlang
   i. Exponential
   j. Chi Square
   k. Beta
   l. Poisson
   m. Pascal
   n. Geometric
   o. Binomial
   p. Hypergeometric

2. Output options

   a. Relative Frequency Distributions
   b. Cumulative Frequency Distributions
   c. Mean
   d. Standard Error
   e. Coefficient of Variation
   f. Mode
   g. Measure of Kurtosis
   h. Measure of Skewness